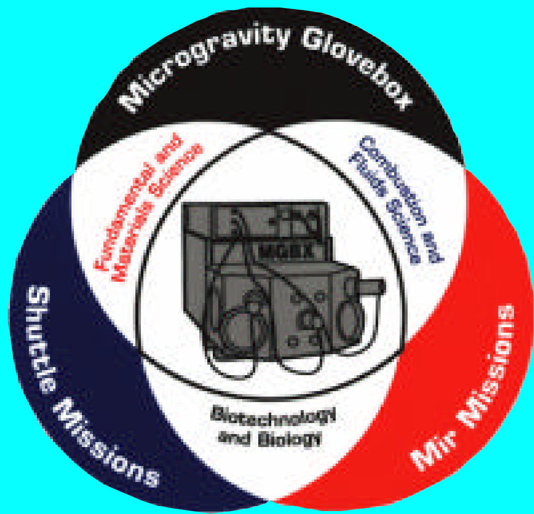


MICROGRAVITY GLOVEBOX INVESTIGATIONS

Introduction

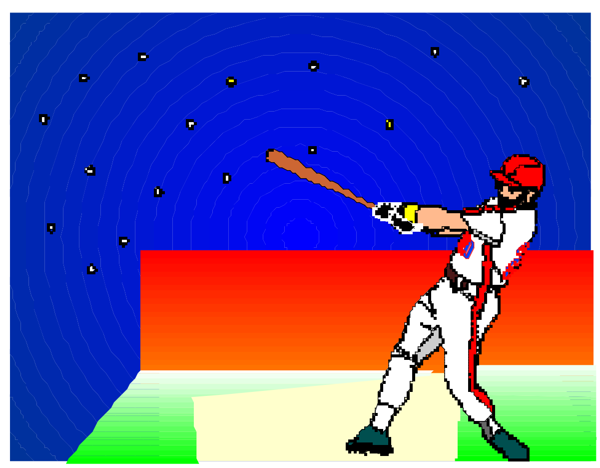
We have no right to assume that any physical laws exist,
or if they have existed up to now,
that they will continue to exist in a similar manner in the future.

Max Planck, physicist
The Universe in the Light of Modern Physics, 1931

WHAT IS GRAVITY?

Gravity anchors us to the ground, prevents the air we breathe from escaping into space, and keeps the Earth orbiting around the Sun. Without gravity, we couldn't hit a baseball, walk to the corner store, or search the night sky for the North Star.

Sir Isaac Newton, the first scientist to identify gravity, described this force as the attraction between two masses. In his Laws of Motion, he wrote, "To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts."



In the 300 years since Newton's discovery, scientists have learned a great deal about the laws governing the universe. Still, gravity remains a mystery in many ways.

WHAT IS MICROGRAVITY?

There is one outstandingly important fact regarding Spaceship Earth and that is no instruction book came with it.

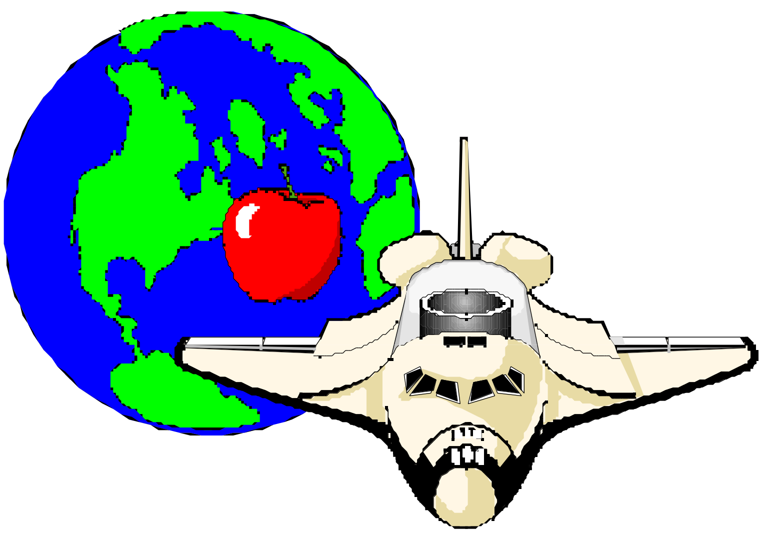
Buckminster Fuller, architect and engineer
Prospect for Humanity, 1964

If we could erase the effects of this invisible force, would Jello jiggle? Would bread dough rise into a tender loaf of bread or would it sink into a hard chunk of yeast and flour? Would a stone skip across a pond or continue on forever?

Space flight, which reduces the effects of gravity, offers scientists the opportunity to conduct experiments that can answer these questions.

MICROGRAVITY: AN ENVIRONMENT

If we drop an apple on Earth, the apple falls and we see gravity in action.



If an astronaut drops an apple on the Space Shuttle, the apple appears to be weightless -- free of gravity. Aboard the Shuttle, the apparent effect of gravity is one-millionth of its strength on Earth, or **microgravity**.

While the apple appears to float, it is actually falling. In fact, the apple, the astronaut, and the Shuttle are falling together -- floating in a state of near weightlessness called "free-fall."

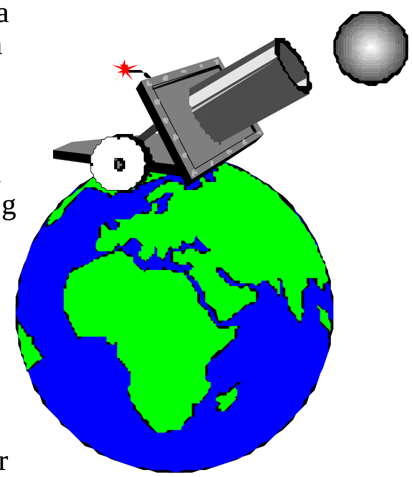
But they are falling towards the Earth at the same time the Earth is curving away from the Shuttle. How does the Shuttle fall around the Earth? Newton explained this curiosity with cannonballs.

MICROGRAVITY: A CONDITION

Physics tries to discover the pattern of events
which controls the phenomena we observe.

James Hopwood Jeans, astronomer and physicist
Physics and Philosophy, 1942

Imagine placing a cannon at the top of a mountain. When we fire the cannon, the cannonball falls to Earth. The greater the speed, the farther the cannonball will travel before landing. The distance is affected by two forces.



First, the force from the explosion propels the cannonball in a straight line. Second, the force of gravity pulls the cannonball down toward Earth. Together, the forces cause the cannonball to travel in an arc, ending at the Earth's surface.

If we could fire the cannon with enough force, the cannonball would continue to fall around the Earth and come back to its starting point. In other words, the cannonball would achieve a state of continuous free-fall, or weightlessness, and orbit the Earth.

The same principle applies to the Space Shuttle.

The gravitational force on the Shuttle orbiting at 480 miles is 91 percent of the gravitational force on the Earth's surface. Because the Earth pulls on the Shuttle, it must travel at 17,000 miles per hour to keep its orbit.

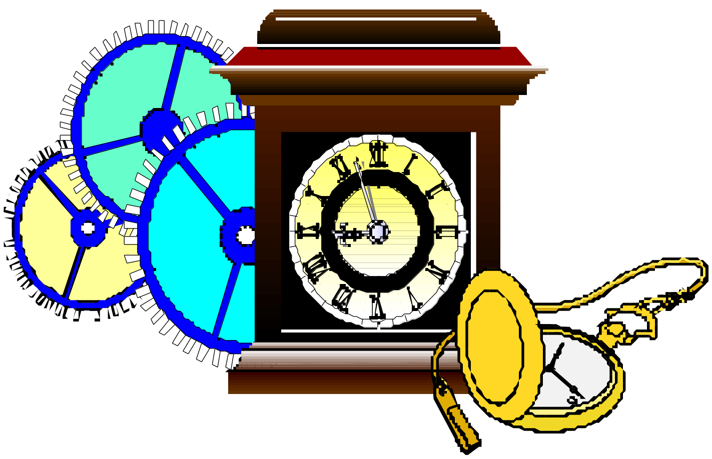
MICROGRAVITY: AN OPPORTUNITY

Many [scientists] are detectives by temperament and many are explorers. Some are artists. . .others are poet-scientists and philosopher-scientists, and even a few are mystics.

Peter Medawar, biologist
The Art of the Soluble, 1967

Before the Age of Electronics, clocks and watches worked by the movement of gears and pendulums. By removing the casing, we could see the gears ticking away the seconds. For scientists, conducting experiments in microgravity reveals the details of fire and fluids just as the gears reveal the way a clock works.

In other words, **microgravity** gives a clearer picture of basic physical processes.



For instance, here on Earth, if we light a candle, we know the heat from the flame will flow upward and the wax will drip downward. If we throw a water-filled balloon, we know the water will splatter in every direction when the balloon hits the ground.

Without gravity, though, will a candle burn? If it does ignite, will the flame flicker and produce smoke? If we throw a water balloon, will it break? If it does break, will the water scatter in hundreds of tiny beads, collect in one big drop, or form a puddle on the floor?

Just as explorers need to know how to use a map and compass before they can understand navigation, scientists need to learn nature's most basic principles before they can understand the mysteries of the universe.

MICROGRAVITY EXPERIMENTS ON EARTH

One accurate measurement is worth a thousand expert opinions.

Grace Hopper, admiral
United States Navy

Before space flight, scientists conducted microgravity experiments with two Earth-bound methods -- drop towers and aircraft.

A *drop tower* creates microgravity by allowing an object to fall very fast from a high tower. A drop tower resembles the amusement park ride where we are buckled into a harness, cranked straight up, then dropped like a rock. The feeling of lightness on the trip down is like being weightless.

The Demon Drop's 131 foot tower plunges riders at a rate of 55 mph in 2.5 seconds.

With a 205 foot hill and speeds of 72 mph, the Magnum XL-200 simulates the effects of weightlessness.

Aircraft can also create microgravity by flying in steep arcs. These arcs, or *parabolas*, are similar to the first hill on a roller coaster. As we pass over the arc, the feeling of lightness is, again, like being weightless.

The main drawback of these methods is the short time that microgravity exists. In the drop tower, microgravity lasts from 2-5 seconds; aboard the aircraft, microgravity lasts 20 seconds. Both methods are good ways to test theories and hardware designs.

For a more complete picture of processes, however, long-term space flight helps scientists fine tune their knowledge.

MICROGRAVITY EXPERIMENTS IN SPACE

The most beautiful thing we can experience is the mysterious.
It is the source of all true art and science.

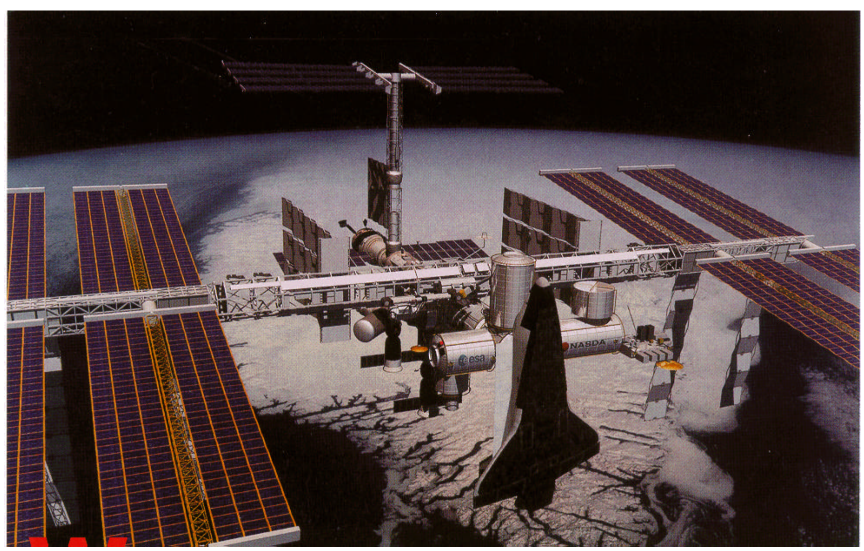
Albert Einstein, physicist
What I Believe, 1930

During Space Shuttle flights, experiments can run for days or weeks. Free from the effects of gravity, scientists can explore slower processes and gain a better understanding than can be achieved on Earth.

From time to time, microgravity experiments were conducted during the Apollo moon program, the Apollo-Soyuz Test Project, and aboard Skylab, America's first space station. Although the early experiments were limited by the spacecraft's size and available power, these experiments raised new ideas and theories about the effects of Earth's gravity.

Since overcoming those limitations, Space Shuttle experiments have been a valuable companion for conventional, Earth-bound science.

In the early 1990's, NASA's Microgravity Science Division initiated a series of microgravity missions designed to advance our knowledge in the physical sciences, improve the quality of life on Earth, and build a foundation for the International Space Station.
These missions brought together leading researchers from universities, industry, and the government to expand the frontiers of science.



The International Space Station.

UNITED STATES MICROGRAVITY LABORATORY: USML

The **United States Microgravity Laboratory (USML**) missions yielded unexpected and provocative results which generated new questions to be explored aboard the International Space Station's long-term microgravity environment.

Catherine Coleman works in the Glovebox.

The first United States Microgravity Laboratory (USML-1) was launched aboard the Space Shuttle *Columbia* during flight STS-50 on June 25, 1992. Glovebox experiments studied fire spread and fluid behavior.

The second United States Microgravity Laboratory 2 (USML-2) was launched aboard the Space Shuttle *Columbia* during flight STS-73 on October 20, 1995. Glovebox experiments studied fluid behavior, particle dispersion, crystallization of hard spheres, and fuel droplet combustion.

UNITED STATES MICROGRAVITY PAYLOAD: USMP

The crew of flight STS-75.

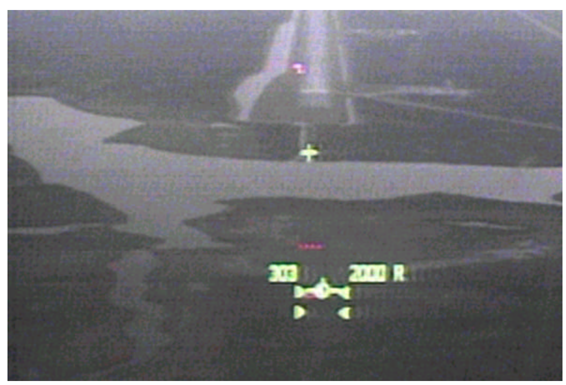
The **United States Microgravity Payload (USMP)** missions provided scientists with the opportunity to conduct research aboard the Shuttle for longer periods of time than available on Earth. By testing new technology, USMP research provided the foundation for advanced joint scientific investigations on the Russian Space Station *Mir* and the International Space Station.

The USMP-3 mission was launched aboard the Space Shuttle *Columbia* during flight STS-75 on February 22, 1996. Glovebox experiments studied the ignition of simple materials, the rate at which fire spreads, and soot formation. In addition, the experiments tested smoke detectors designed for the Shuttle and the International Space Station.

MICROGRAVITY SCIENCE LABORATORY: MSL

The **Microgravity Science Laboratory (MSL)** program continued the success of previous microgravity missions and explored new ways to observe and measure gravity's effect on chemical and physical processes.

The original Microgravity Science Laboratory (MSL-1) was launched aboard the Space Shuttle *Columbia* during flight STS-83 on April 4, 1997. However, problems with a fuel cell forced the Shuttle's early return on April 8. Because only a few of the planned experiments were completed, a second mission (MSL-1R) flew on STS-94 on July 1, 1997. Glovebox experiments studied heat transfer using capillary pumped loops, and the combustion of liquid fuel droplets.



The view from the pilot's seat as the Shuttle lands.

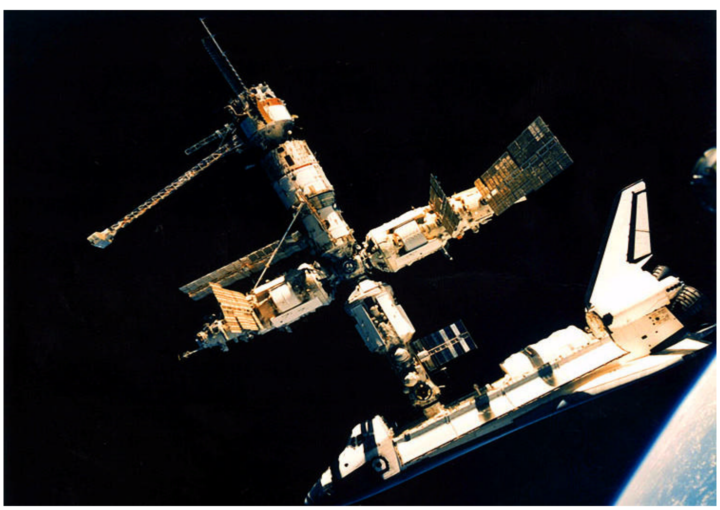
ABOUT THE NASA/*MIRI* MICROGRAVITY PROGRAM

As science progresses, the world-wide cooperation of scientists. . .
becomes a special and distinct community of friendship in which . . .
there is a growing mutually advantageous sharing of work,
a coordination of efforts, a common language for the exchange
of information and solidarity.

Zhores Medvedev, scientist
The Medvedev Papers, 1970

NASA is a partner with the space agencies of Brazil, Canada, Japan, Russia and several European countries. This partnership's mission involves the building of an **International Space Station** where scientists can perform microgravity experiments. While Shuttle missions provide a laboratory for an average of two weeks, the International Space Station will allow experiments to run for months. This extended time will help scientists collect a wide range of data not possible in earlier experiments.

To gain long-duration mission experience, NASA approached Russia with the idea of American astronauts conducting new experiments aboard the **Space Station *Mir.*** In 1994, Russia agreed to the NASA / *Mir* microgravity program of nine Shuttle dockings with *Mir* to exchange experiments and crew.



The Space Shuttle docking with the Space Station Mir.

In 1996, the first Glovebox experiments were performed aboard *Mir*. These experiments studied candle flames and fluids behavior. Since then, additional fluid physics and combustion science Glovebox experiments have been conducted on NASA / *Mir* flights STS-79, STS-81, STS-84, and STS-86.

WHAT IS A MICROGRAVITY GLOVEBOX?

Since the measuring device has been constructed by the observer . . .
we have to remember that what we observe is not nature itself
but nature exposed to our method of questioning.

Werner Karl Heisenberg, physicist
Physics and Philosophy, 1958

Many microgravity space experiments involve large-scale, self-contained modules which are monitored by scientists on Earth. Microgravity Glovebox Investigations, or experiments, involve small-scale modules which are handled by astronauts.

The **Microgravity Glovebox** (MGBX) is a small, tightly sealed box with gloves attached for handling the experiments inside. So far, several dozen low-cost experiments have been conducted in the areas of fluid physics, combustion, biotechnology, and materials science.

Don Thomas sets up an experiment in the Glovebox.

THE PARTS

The Microgravity Glovebox consists of a Glovebox, a Video Drawer, and an Interface Frame.

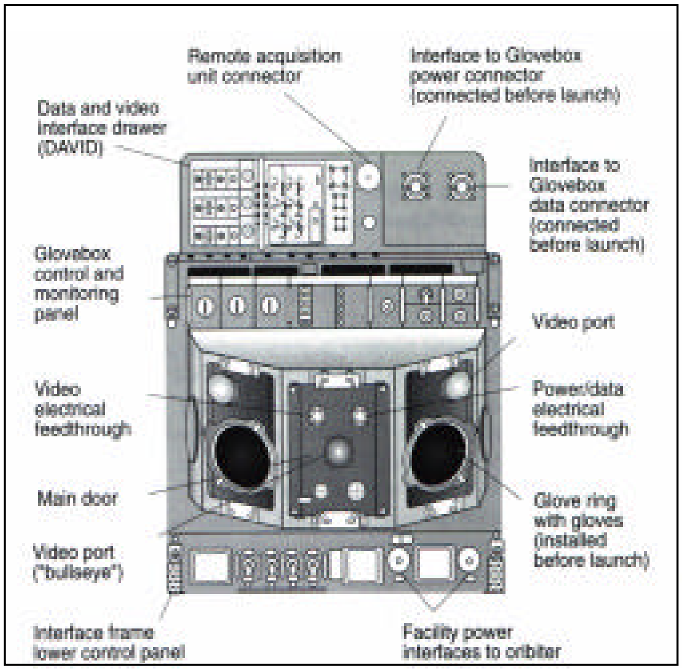


Diagram of the Microgravity Glovebox.

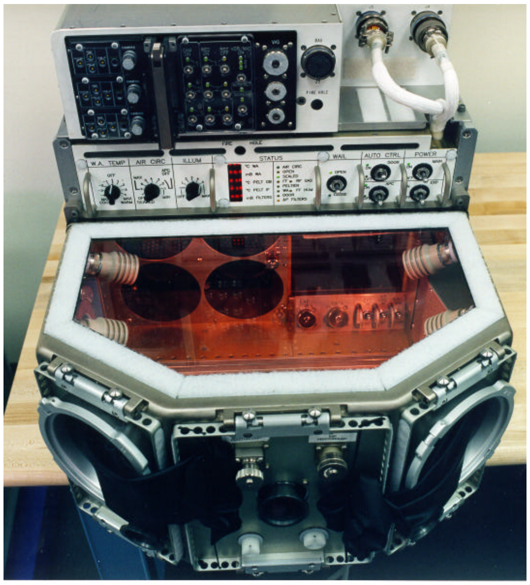
The Glovebox includes a work area and an air management system. The illuminated work area is coated with corrosion-resistant materials, and it is visible through a top window and three front-loaded video port cameras.

Experiments are mounted in the work area. The work area is accessible through three removable door panels and two glove ports.

Two electrical feed-through connectors are available for additional electrical and video operations. The air management system contains filters, valves, and sensors to help regulate filtration, temperature, humidity, gas, and air pressure.

The Video Drawer contains video and audio processing and recording systems. Experiments can be monitored from four camera angles. One video signal can be downlinked to Earth so scientists may request changes to the procedures. External video equipment provides different views of the experiment. An audio switch allows the astronauts to add their comments.

The Glovebox and the Video Drawer are housed in the Interface Frame. The Interface Frame is attached to the Shuttle cabin and provides electrical power, control, and data collection.



Front view of the Microgravity Glovebox.

THE FEATURES

It is impossible to follow the march of one of the great theories of physics . . .
without being charmed by the beauty of such a construction,
without feeling keenly that such a creation
of the human mind is truly a work of art.

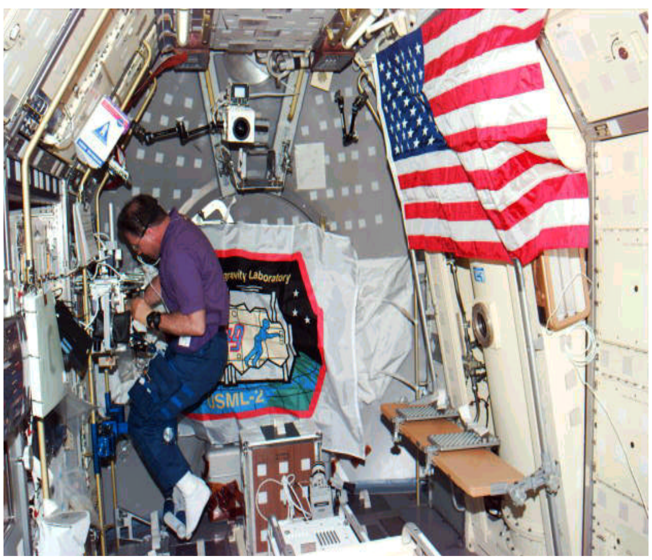
Pierre Maurice Duhem, physicist
The Aim and Structure of Physical Theory, 1906

The Microgravity Glovebox has four important features.

First, the astronauts perform the experiments by hand. If an unexpected situation arises, they make rapid changes on the spot. Second, the sealed Glovebox insures the safety of the crew because the Glovebox isolates the materials used and the by-products produced by the experiments.

Third, the Glovebox provides power, filtration, illumination, data collection, and sensors for measuring gas, temperature, air pressure, and humidity. Fourth, and most importantly, the Glovebox includes photography and videography capabilities to record the experiments.

THE EXPERIMENTS



Albert Sacco makes adjustments to a Glovebox experiment.

Sending experiments into space requires the careful coordination of resources. Since time in space is valuable, the astronauts need to learn each experiment before the flight.

Then, several months before a scheduled flight, most Glovebox experiments are packed in lockers and stored in the Space Shuttle's middeck. During the flight, the astronauts perform the experiments by following the step-by-step instructions posted next to the Glovebox.

While some experiments may last for a few hours, other experiments require several days to test different samples, adjust the hardware, or to change the procedures.

NASA's Microgravity Research Program

From the point of view of the physicist,
a theory of matter is a policy rather than a creed.
Its object is to connect or coordinate apparently diverse phenomena,
and above all, to suggest, stimulate and direct experiments.

Joseph John Thomson, physicist
The Corpuscular Theory of Matter, 1907

NASA's microgravity research program includes Fluid Physics, Combustion Science, Materials Science, Biotechnology, Fundamental Physics, and Technology Demonstrations.

Each area provides new understanding which leads to medical benefits, advanced technology, or scientific education.

Fluid Physics is the study of the behavior of liquids and gases. Information gained from microgravity research is applied to scientific and technical processes.

Combustion Science is the study of the burning process. Information gained from microgravity research advances combustion technology on Earth and enhances fire safety on spacecraft.

Materials Science studies the relationships between the structure, processing, and properties of materials.

Biotechnology research focuses on the growth and structure of protein crystals and the culturing of cells and tissues.

The scientist values research by … its contribution to that huge, logically articulated structure of ideas which… is the most glorious accomplishments of mankind.

Peter Medawar, biologist
The Art of the Soluble, 1967

Fundamental Physics looks at high-priority mysteries in basic physics.

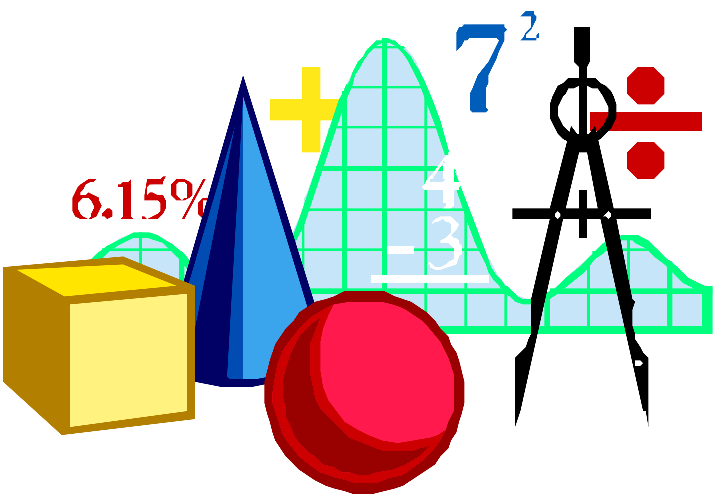
Technology Demonstrations develop and refine the hardware necessary for future microgravity research and space applications.

A Few Words About the Nature of Experiments

The true worth of a researcher lies in pursuing
what he did not seek in his experiment
as well as what he sought.

Claude Bernard, physiologist
From *Bulletin of the New York Academy of Medicine*, 1928

Thomas Edison envisioned the light bulb and then tested hundreds of materials before discovering the right filament -- tungsten fibers.



When scientists ponder a question, they design an experiment, collect data, and analyze the results. Sometimes an experiment tests a theory by adding certain variables. Other times, an experiment tests a theory by removing variables.

While performing experiments in microgravity decreases the effects of gravity, it's important to remember an important fact: on the first try, scientists rarely get the best data and reach a definite conclusion.

Space experiments aren't recipes with completely predictable results. In fact, unpredictability is the nature of experiments.

Mathematical models, however, can provide scientists with an educated guess about the possible outcomes. Sometimes, an experiment will confirm a theory. Other times, parts of a theory will be disproved. Most often, unexpected results will raise new questions.

These questions challenge scientists and provide the excitement -- discovering the unknown.

THE LEWIS RESEARCH CENTER'S MICROGRAVITY RESEARCH PROGRAM

Science throws her treasures,
not like a capricious fairy into the lap of a favored few,
but into the laps of all humanity,
with a lavish extravagance that no legend ever dreamed of.

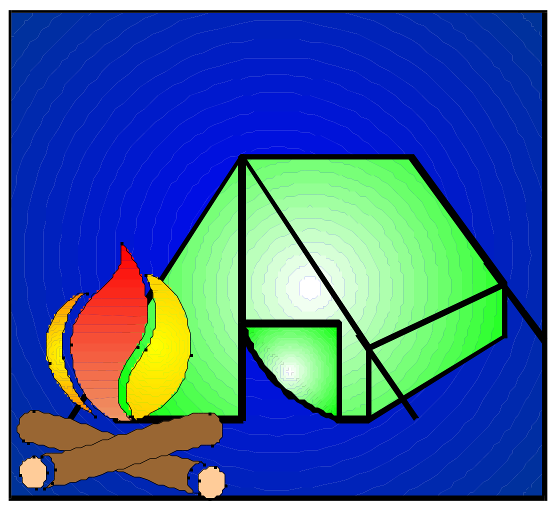
Ernst Mach, physicist and philosopher
The Economical Nature of Physical Inquiry, 1882

As NASA's experts for microgravity research in Combustion Science and Fluid Physics, NASA's Lewis Research Center sponsors a variety of Glovebox investigations in these areas.

WHAT IS COMBUSTION SCIENCE?

Question: What do automobiles, nylon fabric, marshmallows and campfires have in common?

Answer: They all depend on **combustion** -- the chemical reaction that consumes a fuel, releases energy, and produces by-products such as soot, smoke, and exhaust.



Since humans first walked on Earth, fire has been a continuing source of comfort and mystery. In some respects, civilization hasn't advanced very far. Combustion still plays a key role in heating and lighting our homes, weaving yarn into fabric, and processing food products.

Yet after years of study, scientists are just now beginning to understand the rapid and complex chemical processes of combustion.

At the most basic level, **combustion** occurs when fuel, oxygen, and a source of ignition come together in the right manner.

Consider an ordinary example of combustion -- a birthday candle. On Earth, we know these facts.

- The yellow, teardrop-shaped flame contains carbon soot particles.
- Capillary action pulls the melting wax from the candle, up the wick, toward the flame.
- Combustion produces water, carbon dioxide, and soot. When a cold spoon is held over the yellow flame, water condenses on the spoon. When the spoon is placed into the yellow part of the flame, soot blackens the spoon.
- When the flame dies, vaporized hydrocarbons create a trail of smoke.
- When a lighted match is placed in the smoke, the flame jumps down and relights the wick.

With the naked eye, we see only the visible elements of combustion. However, by filtering certain factors, we can see the hidden processes of combustion.

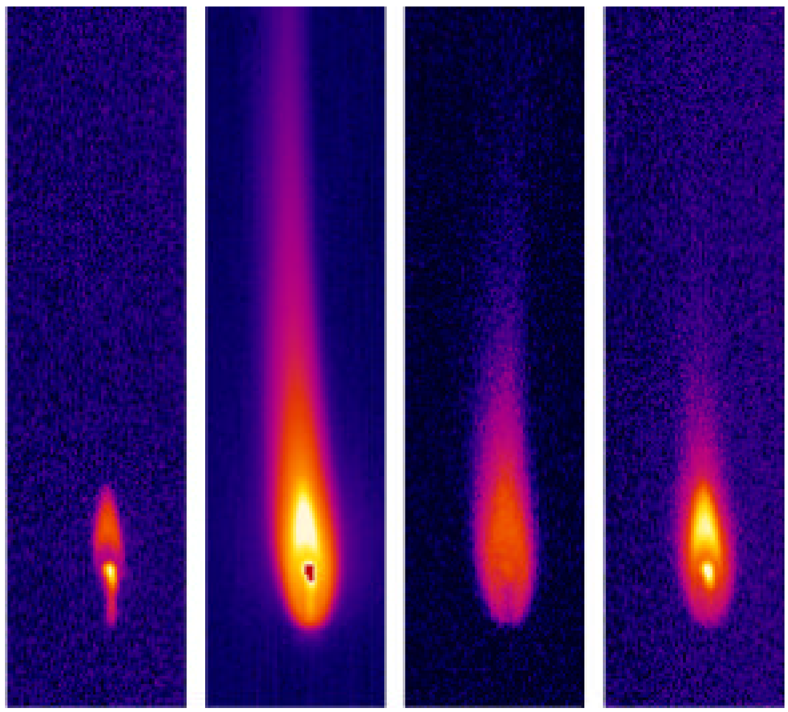
For instance, this series of infrared photographs recorded the combustion of a single birthday candle.

The first image shows the part of combustion we can see.

The second image shows the plume of heat above the flame. The wick is the red dot in the center of the yellow-colored flame.

The third image shows the carbon dioxide produced by combustion.

The fourth image shows the water produced by combustion.



The combustion process of a single birthday candle. Left to right: The visible flame, the heat plume, the carbon dioxide, and the water.

But what happens to a birthday candle in microgravity?

What color is the flame? How is it shaped? Is smoke or soot produced? How much? How long does the flame burn? What happens to the wax? And, does convection affect the candle's combustion?

Convection is the flow within a liquid or gas. In **buoyant convection**, lighter molecules rise to the top, while cooler, heavier molecules are pulled down by gravity. Also known as **buoyancy-induced flows**, convection occurs when we heat soup.

At the bottom of the pan, the hot soup expands and becomes lighter. On the surface, the cooler, denser soup is pulled down by gravity and the hotter, lighter soup rises to the surface.

Convection also affects the temperature of a room; warm air rises to the ceiling while cool air sinks to the floor. Since a fire's smoke is carried in the warm air, smoke detectors are installed on the ceiling.

In microgravity, where up and down do not exist, combustion presents more questions than answers. Glovebox experiments have provided evidence that candle flames form blue balls and the wax does not drip. Soot forms differently. Smoke doesn't rise.

So here's a simple question: "Where should the smoke detectors be located on a spacecraft?"

Combustion Science research sheds new light on the role of gravity in the process of burning. Combustion Science studies the way materials -- gases, liquids, and solids -- ignite and perhaps smolder, as well as the way their fires spread or extinguish.

Scientists study the way heat is released in a flame, the way heat ignites additional fuel, and the way heat is extracted to do a task. They observe the way oxygen comes to the flame and how air and other gases affect the heating of unburned fuel. Finally, scientists study the way a fuel's shape and size affect the heat released in fire.

What Is Fluid Physics?

From the most ancient subject we shall produce the newest science.

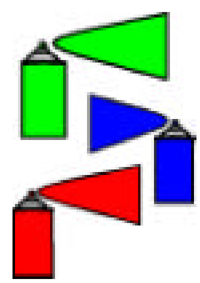
Hermann Ebbinghaus, psychologist
Memory, 1885

We don't pay much attention to the way liquids and gases affect our lives. But Fluid Physics plays a key role in snapping the top from a can of soda pop, welding frames for automobiles and airplanes, and manufacturing computer chips. In fact, fluids are the foundation of power generation, refrigeration, aeronautics, and aerospace.

Fluid Physics research studies the ways liquids and gases behave and how to apply the understanding to fluid systems. Gravity, however, hides the true nature of fluids. For example, if we knock over a pitcher of lemonade on Earth, we know the lemonade will spread over the table, drip down the sides, and form a puddle on the floor. Or, if we spray a window screen with a garden hose, surface tension holds the water droplets against the mesh openings.

In microgravity, when an astronaut spills water, does the water scatter into hundreds of droplets or form a floating ball. More importantly, where does fuel collect in a spacecraft's fuel tanks? Will the fuel form a floating ball? Or, will the liquid hug the inside of the fuel tank? Will the fuel move from the tank through the pipes, or will it form liquid slugs?

Fluid Physics research also studies the way bubbles form and move. On Earth, we know the gas bubbles in a can of soda will rise because the gas is less dense than the liquid. During long space voyages, however, bubbles in fluid systems can cause problems. This research will help develop fuel, oxygen, water, and waste recycling processes which may use electric or magnetic fields to move materials in microgravity.



Finally, Fluid Physics research studies colloids. A **colloid** is a mixture of tiny particles of one material mixed with another material. Aerosol paint is a colloid mixture because the gas spray contains liquid paint particles. On Earth, gravity pulls the paint particles to the bottom of the can. In microgravity, the paint particles would stay evenly scattered. Scientists are studying colloid mixtures as the particles become ordered and form crystals.

MICROGRAVITY GLOVEBOX BENEFITS

Space isn't remote at all.
It's only an hour's drive away if your car could go straight upwards.

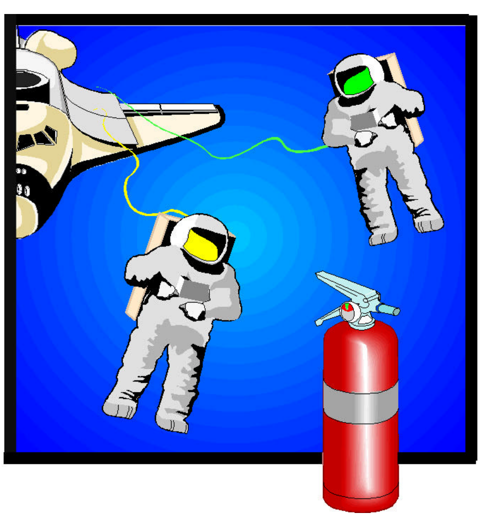
Fred Hoyle, astronomer

BENEFITS OF COMBUSTION SCIENCE ON EARTH

With over 85 percent of the world's energy supplied by combustion, increasing combustion process efficiency by just 2 percent would save the United States more than $8 billion each year. Unfortunately, combustion is also a significant source of pollution to the atmosphere.

On the bright side, NASA discoveries in **Combustion Science** provide fundamental insights to help the nation's research community suggest improvements for increasing engine cycle efficiency, reducing air pollution, and developing technology for industries which use soot in their products. In addition, understanding the way flames start and spread may help fight forest fires, oil field fires, and building fires.

BENEFITS OF COMBUSTION SCIENCE IN SPACE



The astronauts living aboard the Space Station will depend on state-of-the art electronics. But the rules of physics cannot be ignored. Electrical wires create heat, and excess heat in the wires creates fire.

The obvious solution would appear to be smoke detectors. However, detectors require smoke and circulating air to sound the fire alert.

Glovebox combustion experiments have produced important information about the factors affecting flames in microgravity. These experiments emphasized the need for special smoke detectors to alert the astronauts to the presence of fire.

Concern for man himself and his fate must always form the chief interest of all technical endeavors. . .in order that the creations of our mind shall be a blessing and not a curse to mankind.

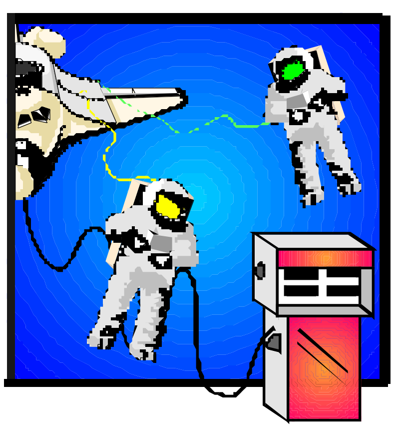
Albert Einstein, physicist
Address, California Institute of Technology, 1931

BENEFITS OF FLUID PHYSICS ON EARTH

Fluid Physics research has increased our knowledge of the behavior of fluids in semiconductor crystal growth, welding, the spread of flames on liquids, and meteorology. Future research has the potential for producing high-strength, temperature-resistant glasses and ceramics needed for power plants. In addition, this research holds the promise of more efficient manufacturing processes for the automotive industry which will increase the United States' competitive edge in the global marketplace.

Fluid Physics research may also improve the environment. With information on the ways pollutants are dispersed into the atmosphere, scientists may develop ways to reduce the amount of air pollution. Finally, with information about the way fluids flow through the human body and other living systems, scientists may gain better insights for improving medical technology.

BENEFITS OF FLUID PHYSICS IN SPACE



During space flight, liquid fuel doesn't collect at the bottom of the fuel tank, warm air doesn't rise, and cool air doesn't sink. After a long day in microgravity, the astronauts can't enjoy a hot shower.

To date, scientists have learned the shape of a container influences the way a liquid behaves in space. This information will help design fuel and oxygen tanks. Other experiments have provided scientists with information necessary for designing cooling equipment for spacecraft and satellites. In short, Microgravity Glovebox fluid physics experiments help engineers design fuel, oxygen, and water systems that work in low levels of gravity.

FLIGHTS, MISSIONS, DATES AND EXPERIMENTS

FLIGHT:	**STS-50 aboard *Columbia***
MISSION:	**United States Microgravity Laboratory 1 (USML-1)**
DATE:	**June 25 - July 9, 1992**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Candle Flames in Microgravity 1	CFM-1	Combustion
*Interface Configuration Experiment 1	ICE-1	Fluids
Oscillatory Thermocapillary Flow Experiment 1	OTFE-1	Fluids
Smoldering Combustion in Microgravity	SCM	Combustion
Wire Insulation Flammability	WIF	Combustion

FLIGHT:	**STS-73 aboard *Columbia***
MISSION:	**United States Microgravity Laboratory 2 (USML-2)**
DATE:	**October 20 - November 5, 1995**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Colloidal Disorder-Order Transition	CDOT	Fluids
Fiber Supported Droplet Combustion 1	FSDC-1	Combustion
*Interface Configuration Experiment 2	ICE-2	Fluids
Oscillatory Thermocapillary Flow Experiment 2	OTFE-2	Fluids

**The report for this experiment is not included in this document.*

FLIGHT: **STS-75 aboard *Columbia***
MISSION: **United States Microgravity Payload 3 (USMP-3)**
DATE: **February 22 - March 9, 1996**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Comparative Soot Diagnostics	CSD	Combustion
Forced Flow Flame Spreading Test 1	FFFT-1	Combustion
Radiative Ignition and Transition to Spread Investigation	RITSI	Combustion

FLIGHT: **Priroda**
MISSION: ***Mir* Increment 2**
DATE: **April 23, 1996**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Candle Flames in Microgravity 2	CFM-2	Combustion
Forced Flow Flame Spreading Test 2	FFFT-2	Combustion
*Interface Configuration Experiment	ICE	Fluids
Technological Evaluation of the Microgravity Isolation Mount	TEM	Fluids

FLIGHT: **STS-79 aboard *Atlantis***
MISSION: ***Mir* Increment 3**
DATE: **September 16, 1996**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Binary Colloidal Alloy Test	BCAT	Fluids

**The report for this experiment is not included in this document.*

FLIGHT:	**STS-81 aboard *Atlantis***
MISSION:	***Mir* Increment 4**
DATE:	**January 12, 1997**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
*Angular Liquid Bridge	ALB	Fluids
Opposed Flow Flame Spread	OFFS	Combustion

FLIGHT:	**STS-84 aboard *Atlantis***
MISSION:	***Mir* Increment 5**
DATE:	**May 15, 1997**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Colloidal Gelation	CGEL	Fluids

FLIGHT:	**STS-94 aboard *Columbia***
MISSION:	**Microgravity Science Laboratory-1R (MSL-1R)**
DATE:	**July 1-17, 1997**

GLOVEBOX EXPERIMENT	ABBREVIATION	TYPE OF EXPERIMENT
Capillary-Driven Heat Transfer	CHT	Fluids
Fiber Supported Droplet Combustion 2	FSDC-2	Combustion

**The report for this experiment is not included in this document.*